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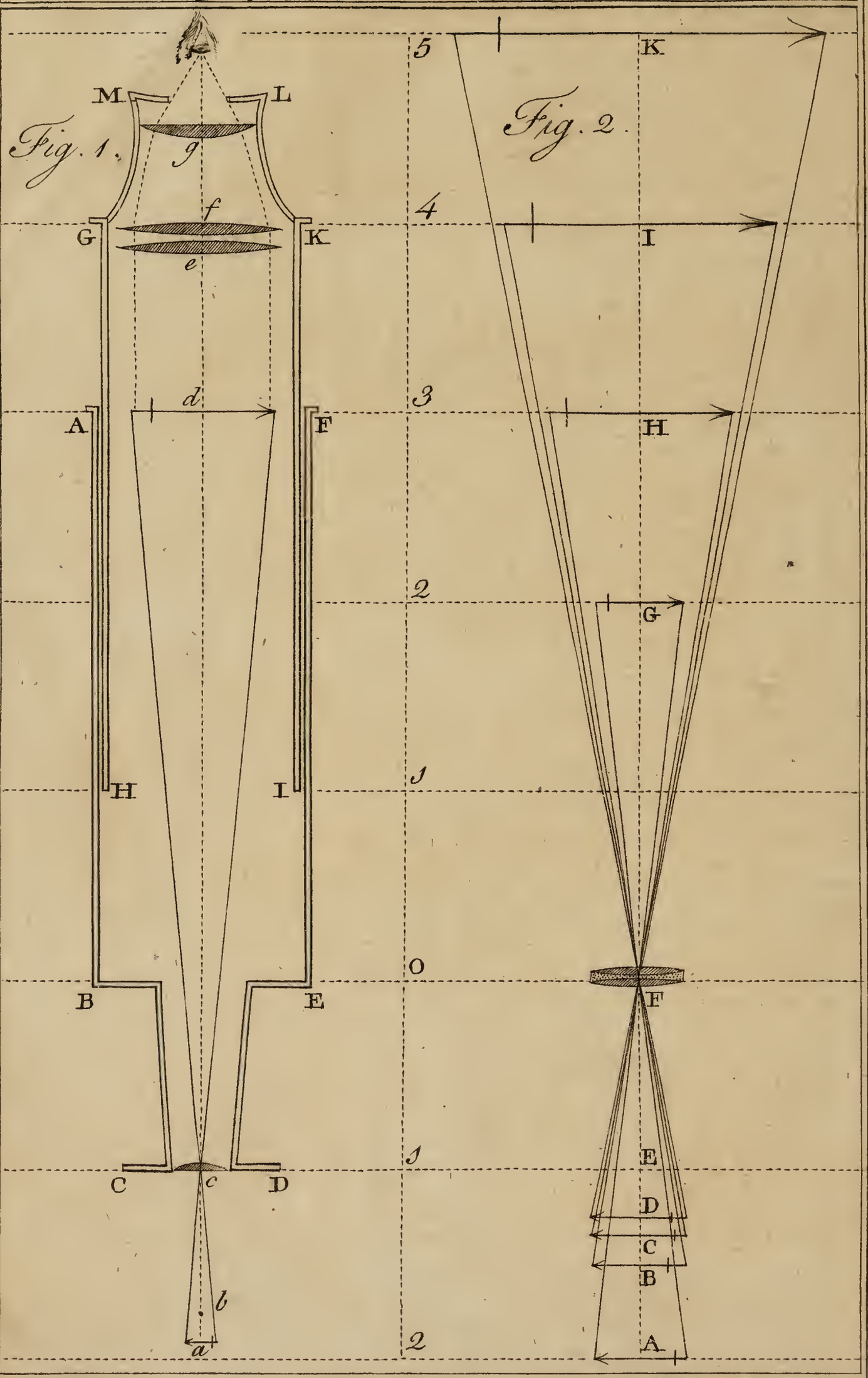
The Polydynamic MICROSCOPE



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Microſcopium Polydynamicum:

OR, A

NEW CONSTRUCTION

OF A

MICROSCOPE,

Wherein a VARIETY of

Magnifying POWERS

Is communicated to each Object-Lens; ſo that by Four Lenſes only, more than *One* HUNDRED different Magnifying Powers are immediately attainable in this Form. Alſo the Method of conſtructing a Microſcope of this Kind *with one Acromatic Lens only*, that will ſhew all Objects from *Jupiter's Moons* in the Heavens, to the *Animalculæ* in Fluids, magnified from Eight to Forty Times *in their linear Dimenſions*.

BY BENJAMIN MARTIN.

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ADVERTISEMENT.

THE Deſcription and Uſe of an univerſal SLIDING RULE, which, by means of *Single* and *Double* SLIDES, and the Addition of proper LINES, is adapted to anſwer all Queſtions in ARITHMETIC, MIXT-MATHEMATICS, and PHILOSOPHY, in the moſt eaſy and expeditious Manner, as ſhewn in Sixty Examples of principal Utility in the practical Parts of Science.

II. The Deſcription and Uſe of a CASE of MATHEMATICAL INSTRUMENTS; particularly of all the LINES contained on the PLAIN SCALE, the SECTOR, the GUNTER, and the *Proportional* COMPASSES. With a practical Application exemplified in many uſeful Caſes of GEOMETRY, and *Plain* and *Spherical* TRIGONOMETRY. The whole illuſtrated by Copper-Plate Figures.

III. The Deſcription and Uſe of a GRAPHICAL PERSPECTIVE and MICROSCOPE, for drawing all Kinds of Objects in true Perſpective, and a juſt Proportion of their Parts, with Readineſs and Eaſe. To which is added, a ſhort Account of an *Opake* SOLAR MICROSCOPE.

IV. The Deſcription and Uſe of an ORRERY of a new Conſtruction, repreſenting in the various Parts of its Machinery all the Motions and Phœnomena of the PLANETARY SYSTEM; to which is ſubjoined a MATHEMATICAL THEORY for calculating the WHEEL-WORK to the greateſt Degree of Exactneſs.

V. The PRINCIPLES of PERSPECTIVE explained in a Genuine Theory, and applied in an extenſive Practice. With the Conſtruction and Uſes of all ſuch Inſtruments as are ſubſervient to the Purpoſes of this SCIENCE.

VI. *Horologia Nova*; or the New ART of DIALLING in THEORY and PRACTICE. In which is demonſtrated, that all the Variety in this Science conſiſts in the Conſtruction of *Three* DIALS only. Alſo the RATIONALE and USE of the LINES of LATITUDES and HOURS, on the DIALLING-SECTOR and TRIGON, with all the requiſite CALCULATIONS. The whole illuſtrated in a large Copper-Plate.

VII. The Deſcription and Uſe of a TABLE-CLOCK upon a new Conſtruction, going by a WEIGHT Eight Days; with a Half-Second PENDULUM of an *invariable* LENGTH, and thereby dividing TIME into HOURS, MINUTES and HALF-SECONDS, with all the Accuracy poſſible. With an Account of the particular PRINCIPLES, derived from NATURE and ART, upon which this new MACHANISM depends.

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THE

DESCRIPTION and USE

OF A *POLYDYNAMIC*

MICROSCOPE.

OF all the *Philoſophical* SCIENCES there is no one whoſe THEORY is ſo extenſive, and at the ſame Time, whoſe *Praxis* is ſo limited and confined, as that of OPTICS, eſpecially with regard to the two noble Inſtruments, the TELESCOPE and the MICROSCOPE; this I have ſhewn in the former Parts of theſe Eſſays, reſpecting the Uſe of the *Teleſcope*, both by *Refraction* and *Reflection*; and to demonſtrate the ſame Thing, ſtill more notorious in the Uſe of the Microſcope, is the Subject of the preſent Eſſay.

To this End it is only neceſſary to conſider, that in every *Compound Microſcope*, the *Magnifier* has but *one Power*, or magnifies an Object *in one certain Degree only*; ſo that a Microſcope with *Six* ſuch Magnifiers, has but *Six Magnifying Powers*; the Reaſon of this is not in the

Glaſs, but in the faulty conſtruction of the Inſtrument; the Glaſs is in itſelf capable of Magnifying to Infinity, were there no foreign Impediments; and ſo far is the *Theory* reducible to *practice, that it is eaſy to conſtruct an Inſtrument wherein the ſame Magnifier that ſhews Jupiter's Moons, ſhall alſo ſhew the Mites in Cheeſe, in any Degree magnified you pleaſe, from* 8 *to* 40 *Times.*

This Propoſition will appear leſs paradoxical, if it be conſider'd that every *Teleſcope* is in reality a *Microſcope*; for what are the Planets and Satellites, the Sun and the Moon, and all diſtant Bodies, but *very ſmall Objects?* We only ſee them by enlarging the Optic Angle under which they appear, and this is the Caſe of the *Common Microſcope.*

If the Object be diſtant from the Lens by more than twice the diſtance of the Focus, it is uſual to call the Inſtrument which ſhews it, a *Teleſcope*; but if the Object be placed within twice the Diſtance of the Focus of the Lens, then it is a *Microſcope*; therefore *twice the Focal Diſtance* of the Lens is *the Limit* between the *Teleſcope and Microſcope*; And becauſe in that caſe the Object and its Image made by the Glaſs, are equal, it will be magnified by the Eye-Glaſs only, and that about 8 times; the Inſtrument may then be called a *Megalaſcope.*

In my New TREATISE of *Achromatic* OPTICS the following Theorem is demonſtrated, viz. *If the Diſtance of the Object from the Lens be multiplied by the focal Diſtance of the Lens, and that Product be divided by the Difference of the ſaid Diſtances, the Quotient will be the Diſtance of the Image from the Lens.* And further, it is demonſtrated, *That the Lengths of the Object, and Image made by the Lens, are directly as their Diſtances from it.*

Now by combining theſe two Theorems together, it will follow, *that the ſame Object poſited at different Diſtances*

Diſtances from the ſame Lens, will have an Image form'd by it, conſtantly variable in its Diſtance and Dimenſions, and this conſtitutes the *variable Magnifying Power* of the Lens; and to know what this is, in any particular Caſe, you have the following Rule reſulting from the ſame Theorems, viz. *From the given Diſtance of the Image from the Lens, ſubduct the focal Diſtance; and the Remainder divided by the ſaid focal Diſtance, will quote the Number of Times the Image is bigger than the Object*, which is the Magnifying Power in that Caſe.

For Example; let the Magnifying Power be required when the Image is at the Diſtance of 3 Inches from a Lens, whoſe focal Diſtance is $\frac{3}{4}$ of an Inch; by the foregoing Rule we have $\frac{3-0,75}{0,75}=3$; or the Object is magnified 3 Times in Length and Breadth. If the Eye-Glaſs be of *one Inch* focal Diſtance, it will ſhew the Image 8 Times larger than it would be ſeen at the Diſtance of 8 Inches, by the naked Eye; therefore $8\times 3=24$, or the whole Power of magnifying in that Caſe, is 24 Times.

Again ſuppoſe the Diſtance of the Image from the ſame Lens be 4 Inches; then, per Rule, $\frac{4-0,75}{0,75}=4,3$; therefore $8\times 4,3=34,4$ the magnifying Power in this Caſe.

Laſtly; let the Diſtance from the Lens be 5 Inches, then $\frac{5-0,75}{0,75}=5,66$; and $5,66\times 8=45,3$ which is the whole Magnifying Power at the given Diſtance of 5 Inches. And thus you proceed for any other Lens, and Diſtance of the Image from it.

Hence it is evident, that, in order to give a Variety of Magnifying Powers to the ſame Microſcopic Lens, nothing more is neceſſary than ſuch a Conſtruction of the

Microſcope as will admit of the Eye-Glaſs (or Glaſſes) being removed or placed at different Diſtances from the Object Lens, or Magnifier; and this Form of a Microſcope is repreſented in Fig. I. conſiſting of the following Parts.

ABCDEF is the outer Caſe or Tube.

GHIK the inner Tube, or Drawer, to be moved up or down in the other.

GKLM the Eye-Piece containing the Glaſſes.

CD the Foot by which the Microſcope is ſcrew'd faſt into a Braſs Frame or Stand, in ſome Forms.

a an Object to be view'd.

c one of the Lenſes or Magnifiers.

b the Focus of the ſaid Lens.

d the Image of the Object *a*.

e, *f*, *g*, the Eye-Glaſſes by which it is view'd.

The Parallel Lines which run acroſs the Plate are drawn at one Inch Diſtance from each other, that the Meaſures of the ſeveral Parts of the Inſtrument may the better appear; thus the Tubes are each 3 Inches long; the inner Tube is drawn out one Inch in the Figure; the Focal Diſtance of the Lens *c* is $cb = \frac{3}{4}$ of an Inch; the Diſtance of the Image *c d* is 4 Inches. When the Tube is not drawn out, the Image is diſtant 3 Inches from the Lens *c*; and when it is drawn out 2 Inches, the Diſtance of the Image is 5 Inches.

In this Microſcope, therefore, there is a variable Diſtance of 2 Inches in which the Image of the Object may be form'd from the Lens *c*; and if $cb = \frac{3}{4}$, there will by this means a variable Power of Magnifying from 24 to 45 Times, as we have ſhewn. And thus the Lens *c* acquires no leſs than 21 different Powers of magnifying in this Microſcope, whereas in all others, it has but *one Single* Power.

In

In the ſame Manner it is ſhewn, that if the Lens *c* be of 1 Inch focal Diſtance, it will magnify from 16 to 32 Times; and has therefore 16 various Magnifying Powers.

A Lens whoſe focal Diſtance is $cb = \frac{1}{2}$ an Inch, will magnify from 40 to 72 Times; and has therefore 32 Powers of Magnifying Objects.

Laſtly, ſuppoſe the focal Diſtance $cb = \frac{3}{10}$ of an Inch; then ſuch a Lens will magnify from 72to 125 Times, or has a variable Power of Magnifying in 53 different Degrees. From theſe Inſtances it appears, that *Four Magnifiers*, which, in theCommon Conſtruction of a Microſcope, can have but 4 different Powers of magnifying, have in this new Form no leſs than 104, *viz.* all from 16 to 125: and therefore it muſt merit with the greateſt Propriety, the Title of a *Polydynamick Microſcope.*

I have ſaid nothing of a Lens of $\frac{2}{10}$ or $\frac{1}{10}$ focal Diſtance, becauſe there are but ſome particular Caſes where they will admit of this *Encreaſe of Magnifying Power*, eſpecially the laſt, which without drawing up the inner Tube at all, magnifies of itſelf 232 Times; and if the ſaid Tube be raiſed 2 Inches, viz. to N°. 5. on the Tube, it will magnify no leſs than 392 Times; and conſequently too much for any common Purpoſes. But I ſometimes meet with Caſes, particularly thoſe where exceeding ſmall Objects are to be meaſured with the MICROMETER, that will bear that very great Magnifying-Power; and therefore I have given the Magnifying Power of *Six Lenſes* in the following Table for every $\frac{1}{4}$ of an Inch encreaſe of Diſtance of the Image from the Lens, from 3 to 5 Inches, by drawing up the Tube GHIK from 3 to 5 upon the Scale engraved thereon.

This Table wants very little Explanation; the firſt Column contains the *Inches and Quarters*, at which the Image is form'd from the Lens. The other Columns belong

Dist. of the Image from the Lens.	First Lens 1 Inch.		Second Lens $\frac{3}{4}$ Inch.		Third Lens $\frac{1}{2}$ Inch.		Fourth Lens $\frac{3}{10}$ Inch.		Fifth Lens $\frac{2}{10}$ Inch.		Sixth Lens $\frac{1}{10}$ Inch.	
	Object to Image.	Mag. Power.	Object to Image.	Mag. Power.	Object to Image.	Mag. Power.	Object to Image.	Mag. Power.	Object to Image.	Mag. Power.	Object to Image.	Mag. Power.
3.	1:2	16	1:3	24	1:5	40	1: 9	72	1:14	112	1:29	232
$\frac{1}{4}$	1:2,25	18	1:3,33	26,66	1:5,5	44	1: 9,83	78,66	1:15,25	122	1:31,5	252
$\frac{1}{2}$	1:2,5	20	1:3,66	29,33	1:6	48	1:10,66	85,33	1:16,5	132	1:34	272
$\frac{3}{4}$	1:2,75	22	1:4	32	1:6,5	52	1:11,5	92	1:17,75	142	1:36,5	292
4.	1:3	24	1:4,33	34,66	1:7	56	1:12,33	98,66	1:19	152	1:39	312
$\frac{1}{4}$	1:3,25	26	1:4,66	37,33	1:7,5	60	1:13,16	105,33	1:20,25	162	1:41,5	332
$\frac{1}{2}$	1:3,5	28	1:5	40	1:8	64	1:14	112	1:21,5	172	1:44	352
$\frac{3}{4}$	1:3,75	30	1:5,33	42,66	1:8,5	68	1:14,83	118,66	1:227,5	182	1:46,5	372
5.	1:4	32	1:5,66	45,33	1:9	72	1:15,66	125,33	1:24.	192	1:49	392

long to each reſpective Lens by Pairs; in the firſt of which is contained the Ratio or Proportion of the Object and Image; and in the ſecond is the whole Magnifying Power at that Diſtance. For Example, in the Uſe of the Firſt Lens of 1 Inch Focal Diſtance, the Ratio of the Object to the Image at 4 Inches from the Lens is 1 to 3, and the Magnifying Power is 24 Times. In the Lens of $\frac{1}{2}$ an Inch, the Ratio is 1 to 7, and the Magnifying Power is 56 Times, at the ſame Diſtance of 4 Inches from the Lens.

If

If to theſe a Lens of 1 ½ Inch be added, then when the inmoſt Tube is quite down, and the Image form'd at the Diſtance of 3 Inches from the Lens, it will be juſt as large as the Object, which muſt then be placed alſo at the Diſtance of 3 Inches below. In this Caſe, there is no magnifying by the Lens, but only by the Eye Glaſs, 8 times. And when the inner Tube is rais'd to 5 on the Scale, the Image will be to the Object as 7 to 3, or as 2 ⅓ to 1; and therefore the whole Power of magnifying will be 18,66 Times; ſo that with ſuch a Lens, this *Polydynamic Microſcope* will magnify in all Degrees from 8 to 400 Times, in Length and Breadth.

With reſpect to the Eye-Glaſs, it is here always ſuppoſed to be of 1 *Inch Focal Diſtance*, whether it conſiſts of a Single Glaſs as (*e*); or of two Glaſſes combined, as *e*, *f*; or three Glaſſes as *e*, *f*, *g*; this laſt Set of Eye-Glaſſes is much the beſt on many Accounts; but if they are not of a proper focal Diſtance, and placed at requiſite Intervals, all Computations of the magnifying Powers will be vain, and the Scale and Table here adapted to it, will be uſeleſs.

If it ſhould at any Time happen, that you have a Lens different from any in the Table, the Magnifying Power is found for any given Diſtance of the Image (leſs than 5 Inches) by Rule at Page 3. But if you would find the Diſtance of the Image to produce a given Magnifying Power with a given Lens, you do it by the following Rule, viz. *Add Unity to the given Magnifying Power divided by* 8; *multiply that Sum by the given focal Diſtance of the Lens*; *and the Product will be the Diſtance of the Image from the Lens, as required.*

For Example; ſuppoſe it required to magnify an Object juſt 50 Times with a Lens whoſe focal Diſtance is ½ an Inch; what muſt be the Diſtance of the Image from the Lens? Anſwer; the Magnifying Power 50 divided

by

by 8 is 6,25; to which add unity, the Sum is 7,25; this multiplied by the given focal Diſtance of the Lens 0,5, is 3,625 Inches, the Diſtance ſought. That is, the Tube GHIK being raiſed to the Number 3,625 upon the Scale, the Inſtrument magnifies the Object then juſt 50 Times.

As all the Novelty of this Conſtruction of a *Polydynamic Microſcope* conſiſts wholly in the Body-Part (as it is call'd) it is plain, it may be applied in any of the common Forms of *Compound Microſcopes*, and with all the ſame *Apparatus*.

This is the laſt Improvement of the Microſcope that I can think of, in relation to its *eſſential Parts*; the moſt inquiſitive and ſcrupulous *Connoiſſeur* will by this Conſtruction have it in his Power to view Objects every way, by Single Lenſes, or by a Compoſition of them; magnified in any Degree he pleaſes; and capable of being meaſured with eaſe in all their Dimenſions by a moſt exact Micrometer.

In former Tracts I have ſhewn that both *Reflecting and Refracting Teleſcopes*, are, in their own Nature, *Univerſal Perſpectives*, or may be conſtructed and adapted to magnify every Sort of Objects; but at the ſame Time, it muſt be confeſt, this was done by a Combination of different Mirrors, and Lenſes, in the ſaid Inſtruments. In the preſent Eſſay it is propoſed to give a further Illuſtration of the Simplicity and Univerſallity of Optical Conſtructions by an Example of the Application of *one and the ſame Lens* as an Object-Glaſs in a Teleſcope for viewing diſtant Bodies on one hand, and in a Microſcope for magnifying all Kinds of ſmall Objects on the other; and that with various Degrees of Magnifying Power in each Caſe.

It is preſumed that no Perſon curious in Optics can be unacquainted with the *Patent-Opera* conſtructed with 4 Con-

Concaves, and therefore with ſo many different Magnifying Powers for ſhewing diſtant Objects as a Teleſcope; and that, by the greateſt Magnifier, *Jupiter's Moons* may be ſeen.

Now the very ſame *Achromatic Lens*, if applied in the preceeding Conſtruction, will become the Object-Lens of an *Achromatic and Polydynamic Microſcope*; and which will magnify in every degree from 8 to 40 or 50 times, as will be evident by contemplating Fig. 2. where F is the *Achromatic Lens*; its focal Diſtance FE; and A, B, C, D, ſuch Poſitions of the Object below it, as will make the Images G, H, I, K, above it, in proportion to the Object, as the numbers 1, 2, 3, 4, &c. to 1.

Hence ſince the Image at G, is 1, or equal to the object, it is at the ſame Diſtance from the Lens, or FG = FA = 2FE; and the Magnifying Power is now only by the Eye-Glaſs, ſuppoſe 8 times.

The Image at H being as 2, or twice as big as the Object now at B, will double the Magnifying Power, or make it 16 times.

In like manner the Image I being 3 times as large as the Object at C, will produce a Power of Magnifying 24 times; and the Image at K, 4 times as long as the Object, will cauſe a Magnifying Power of 32 times, and thus you may proceed for a Power of magnifying 40 or 50, and, in ſome Caſes, even to 60 times.

But a Power of Magnifying 40 times will be found full ſufficient to give a moſt delightful View of all ſmall Objects in General, as the Aperture here exceeds that of a Common Microſcope as much as it does a common Teleſcope when uſed as ſuch; being from 3 to 6 *Tenths* of an Inch in that Lens which ſhews Jupiter's Moons. And therefore the Quantity of Light is very great, and renders the View of all Objects, equally agreeable and pleaſant,

However I find by Experience with *three ſeveral Achromatic* Lenſes of different focal Lengths, that the Image will not bear to be encreaſed beyond 5 or 6 times, for after that, it becomes indiſtinct, as in Common Microſcopes. And for great Powers of Magnifying exceeding ſmall Objects, as the Particles of Blood, &c. we muſt be content with our Common Lenſes, which do extremely well indeed, and I very much queſtion if they will ever be equalled by any achromatic Microſcopic Lenſes of ſhort focal Diſtances, that may hereafter be made.

It would be well worth any Gentleman's while, who has got one of the Patent or *Achromatic Operas*, to have it converted into a Microſcope of the Sort now deſcribed; for the inſtrument being ſcrewed upon the Lid of the Box (which contains it) will ſtand on the Floor, and the upper part will reach the Eye as you ſit in a Chair, and give an Opportunity of viewing Objects with the utmoſt Eaſe and Conveniency.

I think no one can now doubt, that one and the ſame Lens F will ſhew every Object in Nature as far as a Power of Magnifying 50 times will go; If any Scruple ſhould remain concerning ſuch univerſallity in the Uſe of One *Lens only*, it is in any Perſon's Power to have them removed by Experiment whenever they pleaſe; ſo nothing more needs be ſaid upon that Head.

It will require but few Words to obſerve (in Concluſion of this Subject) That as the Images at G, H, I, K, &c. are as 1, 2, 3, 4, &c. ſo the Diſtances ED, EC, EB, EA, will be $\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{2}$, $\frac{1}{1}$ of the Line AE; and conſequently the ſaid Line AE will be divided in *Harmonical Proportion* in the Points B, C, D, &c. or Places of the Object, for producing Images in *Arithmetical Progreſſion*, as are thoſe in the Figure.

FINIS.